

# Periodicity Introduction

## Periodic Table of Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 <b>H</b> Hydrogen 1.00794	<div> <div>Atomic #</div> <div>Symbol</div> <div>Name</div> <div>Atomic Mass</div> </div> <div> <div>C Solid</div> <div>Hg Liquid</div> <div>H Gas</div> <div>Rf Unknown</div> </div> <div> <div>Metals</div> <div>Alkali metals</div> <div>Alkaline earth metals</div> <div>Actinoids</div> <div>Lanthanoids</div> <div>Transition metals</div> <div>Poor metals</div> <div>Other nonmetals</div> <div>Noble gases</div> </div>																2 <b>He</b> Helium 4.002602
3 <b>Li</b> Lithium 6.941	4 <b>Be</b> Beryllium 9.012182											5 <b>B</b> Boron 10.811	6 <b>C</b> Carbon 12.0107	7 <b>N</b> Nitrogen 14.0067	8 <b>O</b> Oxygen 15.9994	9 <b>F</b> Fluorine 18.9984032	10 <b>Ne</b> Neon 20.1797
11 <b>Na</b> Sodium 22.98976928	12 <b>Mg</b> Magnesium 24.3050											13 <b>Al</b> Aluminum 26.9815386	14 <b>Si</b> Silicon 28.0855	15 <b>P</b> Phosphorus 30.973762	16 <b>S</b> Sulfur 32.065	17 <b>Cl</b> Chlorine 35.453	18 <b>Ar</b> Argon 39.948
19 <b>K</b> Potassium 39.0983	20 <b>Ca</b> Calcium 40.078	21 <b>Sc</b> Scandium 44.955912	22 <b>Ti</b> Titanium 47.887	23 <b>V</b> Vanadium 50.9415	24 <b>Cr</b> Chromium 51.9961	25 <b>Mn</b> Manganese 54.938045	26 <b>Fe</b> Iron 55.845	27 <b>Co</b> Cobalt 58.933195	28 <b>Ni</b> Nickel 58.6934	29 <b>Cu</b> Copper 63.546	30 <b>Zn</b> Zinc 65.38	31 <b>Ga</b> Gallium 69.723	32 <b>Ge</b> Germanium 72.64	33 <b>As</b> Arsenic 74.9216	34 <b>Se</b> Selenium 78.96	35 <b>Br</b> Bromine 79.904	36 <b>Kr</b> Krypton 83.798
37 <b>Rb</b> Rubidium 85.4678	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.90585	40 <b>Zr</b> Zirconium 91.224	41 <b>Nb</b> Niobium 92.90638	42 <b>Mo</b> Molybdenum 95.96	43 <b>Tc</b> Technetium (97.9072)	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.90550	46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.8652	48 <b>Cd</b> Cadmium 112.411	49 <b>In</b> Indium 114.818	50 <b>Sn</b> Tin 118.710	51 <b>Sb</b> Antimony 121.760	52 <b>Te</b> Tellurium 127.60	53 <b>I</b> Iodine 126.90447	54 <b>Xe</b> Xenon 131.293
55 <b>Cs</b> Cesium 132.9054519	56 <b>Ba</b> Barium 137.327	57-71	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.94788	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.207	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.222	78 <b>Pt</b> Platinum 195.084	79 <b>Au</b> Gold 196.966569	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.3833	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98040	84 <b>Po</b> Polonium (209)	85 <b>At</b> Astatine (210)	86 <b>Rn</b> Radon (222)
87 <b>Fr</b> Francium (223)	88 <b>Ra</b> Radium (226)	89-103	104 <b>Rf</b> Rutherfordium (261)	105 <b>Db</b> Dubnium (262)	106 <b>Sg</b> Seaborgium (266)	107 <b>Bh</b> Bohrium (264)	108 <b>Hs</b> Hassium (277)	109 <b>Mt</b> Meitnerium (268)	110 <b>Ds</b> Darmstadtium (271)	111 <b>Rg</b> Roentgenium (272)	112 <b>Uub</b> Ununbium (285)	113 <b>Uut</b> Ununtrium (284)	114 <b>Uuq</b> Ununquadium (289)	115 <b>Uup</b> Ununpentium (288)	116 <b>Uuh</b> Ununhexium (292)	117 <b>Uus</b> Ununseptium	118 <b>Uuo</b> Ununoctium (294)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Design and Interface Copyright © 1997 Michael Dayah (michael@dayah.com). <http://www.ptable.com/>

Ptable.com

57 <b>La</b> Lanthanum 138.90547	58 <b>Ce</b> Cerium 140.116	59 <b>Pr</b> Praseodymium 140.90765	60 <b>Nd</b> Neodymium 144.242	61 <b>Pm</b> Promethium (145)	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.964	64 <b>Gd</b> Gadolinium 157.25	65 <b>Tb</b> Terbium 158.92535	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93032	68 <b>Er</b> Erbium 167.259	69 <b>Tm</b> Thulium 168.93421	70 <b>Yb</b> Ytterbium 173.054	71 <b>Lu</b> Lutetium 174.967
89 <b>Ac</b> Actinium 227	90 <b>Th</b> Thorium 232.03806	91 <b>Pa</b> Protactinium 231.03688	92 <b>U</b> Uranium 238.02891	93 <b>Np</b> Neptunium (237)	94 <b>Pu</b> Plutonium (244)	95 <b>Am</b> Americium (243)	96 <b>Cm</b> Curium (247)	97 <b>Bk</b> Berkelium (247)	98 <b>Cf</b> Californium (251)	99 <b>Es</b> Einsteinium (252)	100 <b>Fm</b> Fermium (257)	101 <b>Md</b> Mendelevium (258)	102 <b>No</b> Nobelium (259)	103 <b>Lr</b> Lawrencium (262)

# Periodic Table

The development of the periodic table brought a system of order to what was otherwise an collection of thousands of pieces of information.

The periodic table is a milestone in the development of modern chemistry. It not only brought order to the elements but it also enabled scientists to predict the existence of elements that had not yet been discovered .

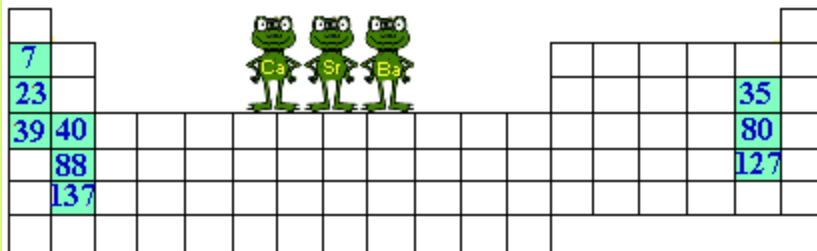
1																		18															
1 H 1.0079																		2 He 4.0026															
2																		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Li 6.941	Be 9.0122																	B 10.811	C 12.011	N 14.007	O 15.999	F 18.998	Ne 20.180										
11 Na 22.990	12 Mg 24.305	3	4	5	6	7	8	9	10	11	12	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.065	17 Cl 35.453	18 Ar 39.948																
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.409	31 Ga 69.723	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.798																
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29																
55 Cs 132.91	56 Ba 137.33	57-71 *	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)																
87 Fr (223)	88 Ra (226)	89-103 *	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)																			
* Lanthanide series																		57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97	
# Actinide series																		89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)	

# Early Attempts to Classify Elements

## ► Dobreiner's Triads (1827)

- Classified elements in sets of three having similar properties.
- Found that the properties of the middle element were approximately an average of the other two elements in the triad.

### Dobereiner's Law of Triads



The diagram shows a simplified periodic table with three triads of elements highlighted in blue. The triads are:

Triad 1	Triad 2	Triad 3
7		
23		
39	40	35
88		80
137		127

Three cartoon frogs are standing on the middle element of each triad (40, 80, 127).



# Newland's Octaves – 1863

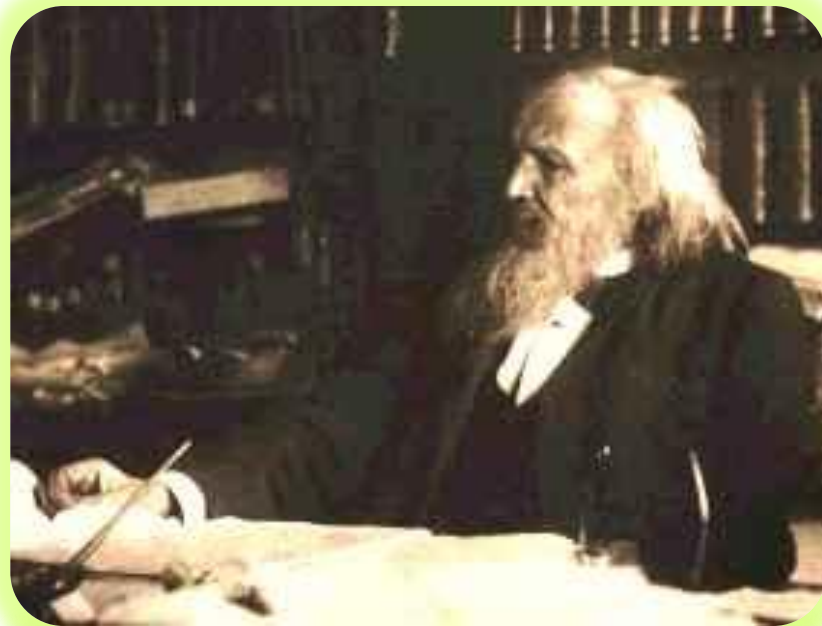


- ▶ **John Newland** attempt to classify 62 known elements
- ▶ He observed that when ordered by Atomic Mass, there was a an observable repetition **every eighth element**
- ▶ Tried to correlate the trends with musical scales, was ridiculed, and eventually awarded for his findings.

# Dmitri Mendeleev

Dmitri Mendeleev is credited with creating the modern periodic table of the elements.

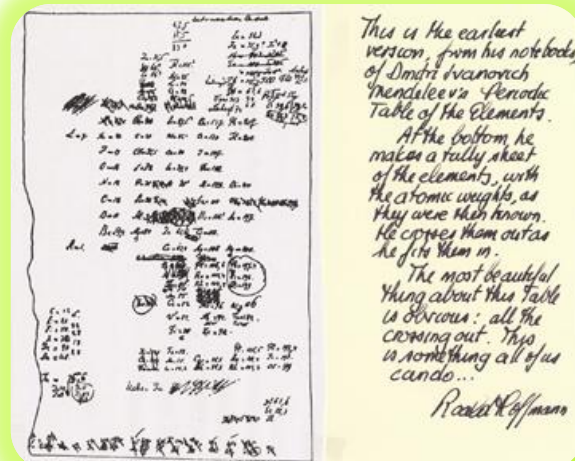
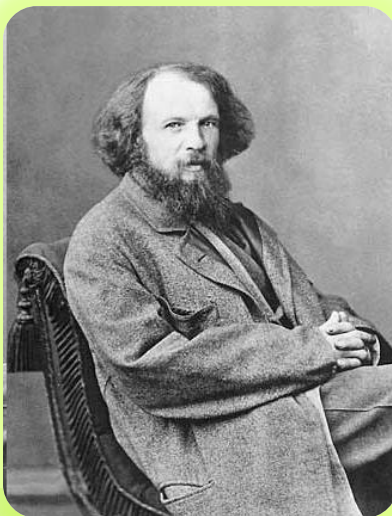
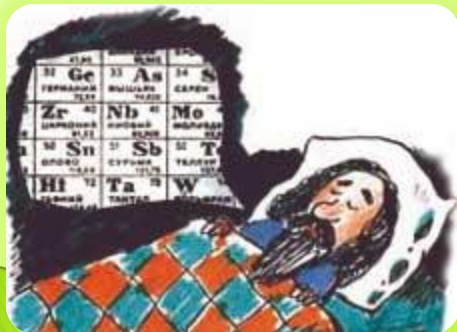
He gets the credit because he not only arranged the atoms, but he also made predictions based on his arrangements. His predictions were later shown to be quite accurate.





# Mendeleev's Periodic Table

- Mendeleev organized all of the elements into one comprehensive table.
- Elements were arranged in order of increasing mass.
- Elements with similar properties were placed in the same row.



# Mendeleev's Periodic Table

T a b e l l e II.

Reihen	Gruppe I. — R <sup>1</sup> O	Gruppe II. — RO	Gruppe III. — R <sup>2</sup> O <sup>3</sup>	Gruppe IV. RH <sup>4</sup> RO <sup>2</sup>	Gruppe V. RH <sup>5</sup> R <sup>2</sup> O <sup>5</sup>	Gruppe VI. RH <sup>6</sup> RO <sup>3</sup>	Gruppe VII. RH R <sup>3</sup> O <sup>7</sup>	Gruppe VIII. — RO <sup>4</sup>
1	H = 1							
2	Li = 7	Be = 9,4	B = 11	C = 12	N = 14	O = 16	F = 19	
3	Na = 23	Mg = 24	Al = 27,3	Si = 28	P = 31	S = 32	Cl = 35,5	
4	K = 39	Ca = 40	— = 44	Ti = 48	V = 51	Cr = 52	Mn = 55	Fe = 56, Co = 59, Ni = 59, Cu = 63.
5	(Cu = 63)	Zn = 65	— = 68	— = 72	As = 75	Se = 78	Br = 80	
6	Rb = 85	Sr = 87	?Yt = 88	Zr = 90	Nb = 94	Mo = 96	— = 100	Ru = 104, Rh = 104, Pd = 106, Ag = 108.
7	(Ag = 108)	Cd = 112	In = 113	Sn = 118	Sb = 122	Te = 125	J = 127	
8	Cs = 133	Ba = 137	?Di = 138	?Ce = 140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	—
10	—	—	?Er = 178	?La = 180	Ta = 182	W = 184	—	Os = 195, Ir = 197, Pt = 198, Au = 199.
11	(Au = 199)	Hg = 200	Tl = 204	Pb = 207	Bi = 208	—	—	—
12	—	—	—	Th = 231	—	U = 240	—	— — — —

Mendeleev left some blank spaces in his periodic table. At the time the elements gallium and germanium were not known. He predicted their discovery and estimated their properties.



# PERIODS -

**SIMILARITIES: THE NUMBER OF  
OUTER ELECTRON SHELLS.**

<div>PERIODS</div> <div>SIMILARITIES: THE NUMBER OF OUTER ELECTRON SHELLS.</div>																	
H											He						
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Se	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds								

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



# GROUPS –

**SIMILARITIES: THE NUMBER OF ELECTRONS IN THE OUTER SHELL. COMMON REACTIVITY, BONDING, CHEMICAL AND PHYSICAL PROPERTIES.**

H	ELECTRONS IN THE OUTER SHELL. COMMON REACTIVITY, BONDING, CHEMICAL AND PHYSICAL PROPERTIES.																He				
Li	Be															B	C	N	O	F	Ne
Na	Mg															Al	Si	P	S	Cl	Ar
K	Ca	Se	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr				
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe				
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn				
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds												
		Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu						
		Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr						

# METALIC PROPERTIES

NON METALS

**SIMILARITIES: AN ELEMENTS  
RELATIVE ABILITY TO CONDUCT  
ENERGY IN THE FORM OF HEAT  
OR ELECTRICITY.**

THE "STAIR"

H	SIMILARITIES: AN ELEMENTS RELATIVE ABILITY TO CONDUCT ENERGY IN THE FORM OF HEAT OR ELECTRICITY.										THE “STAIR”					He	
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Se	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds								

METALS

METALLOIDS

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

# PERIODIC LAW

- ▶ When the elements are arranged in order of **increasing atomic number**, there is a periodic repetition of their physical and chemical properties



# Trends of the Periodic Table

Atomic Radius: A measure of the distance from the center of the nucleus to the outer-most electron

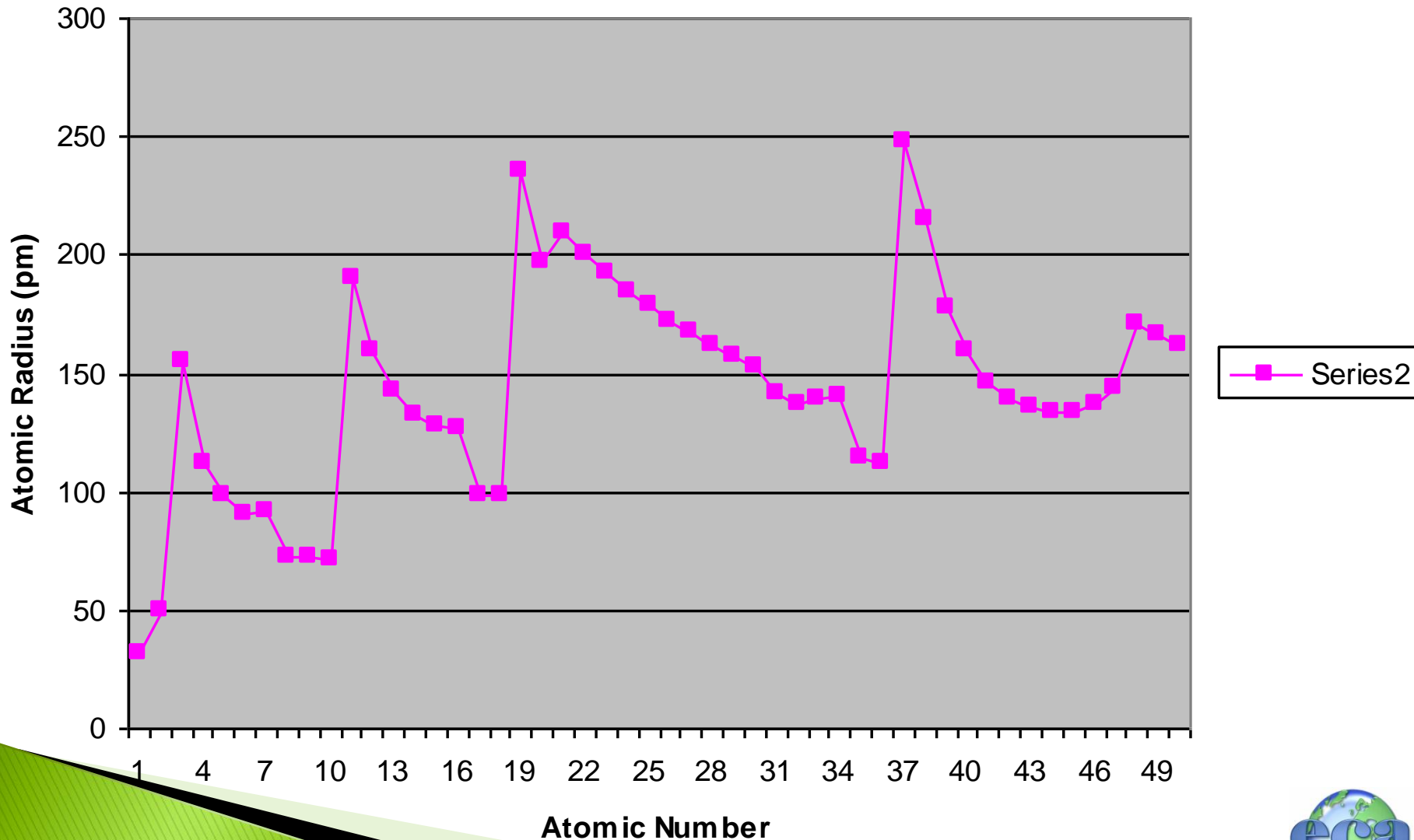
Electronegativity: An atoms ability or affinity to gain another electron.

Ionization Energy: The energy required to lose the outer-most electron from an element.

Reactivity: An atoms general ability to undergo a chemical reaction.

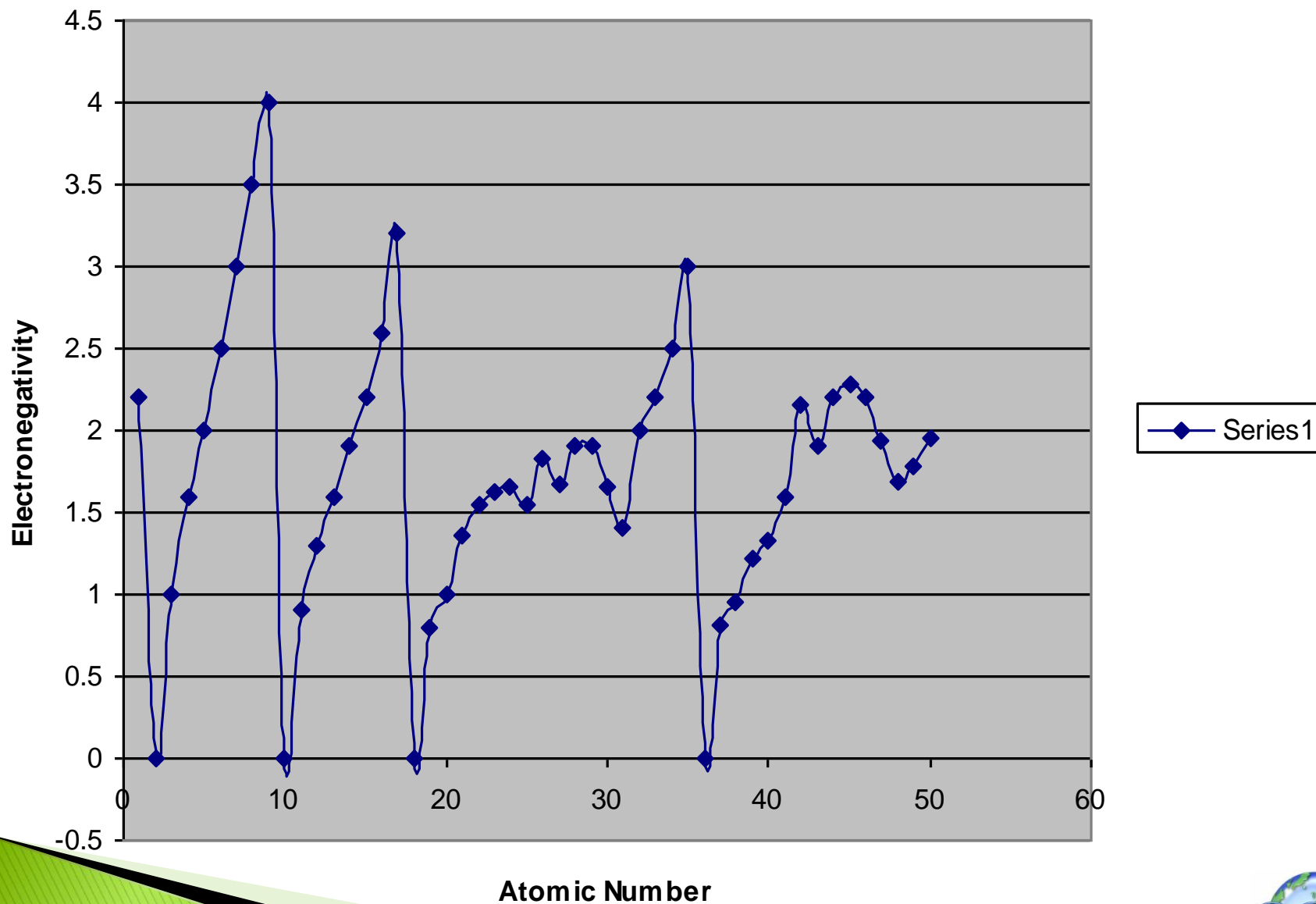


# ATOMIC RADIUS TREND

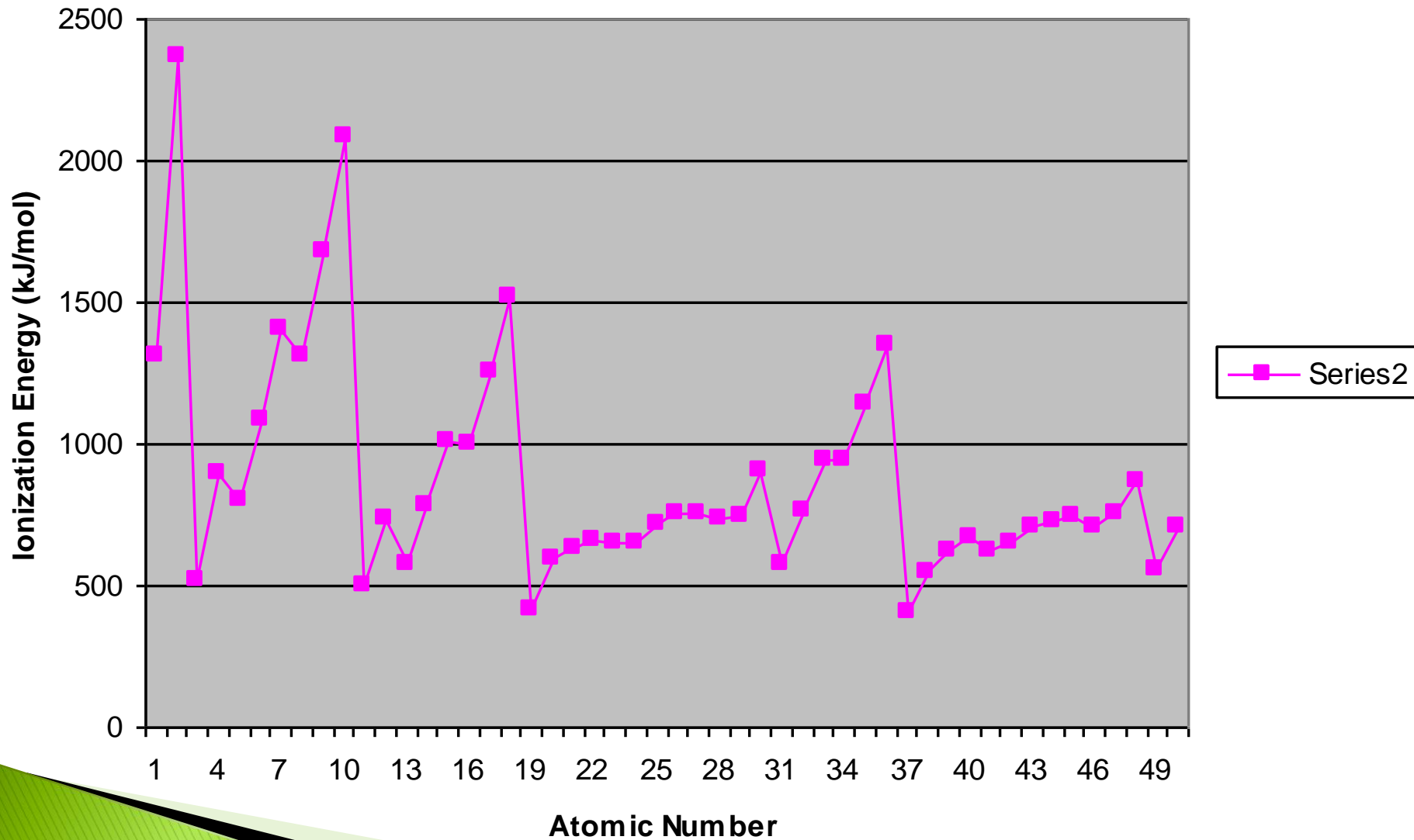




# ELECTRONEGATIVITY TREND



# IONIZATION ENERGY TREND



# 4 MAJOR TRENDS: TOP RIGHT OR BOTTOM LEFT?

The diagram illustrates the periodic table with two prominent trends indicated by large arrows:

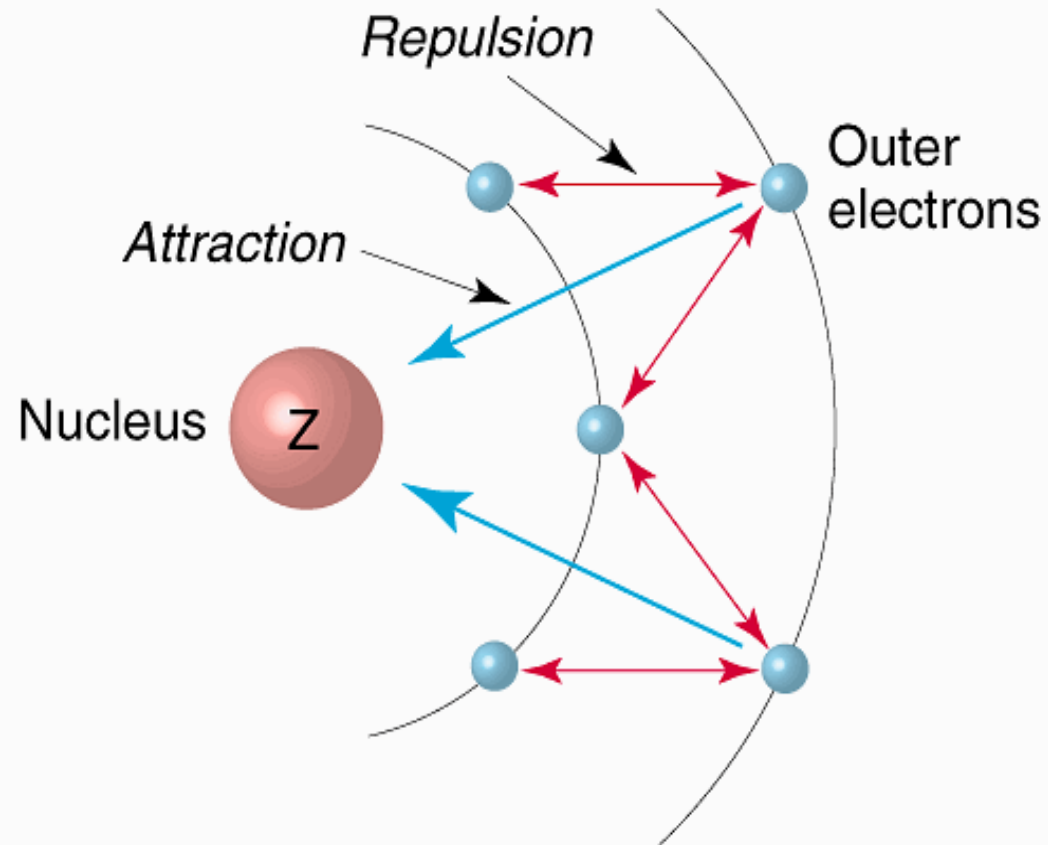
- Electronegativity (F) & Ionization Energy (He):** Indicated by a green arrow pointing from the bottom-left (Francium) towards the top-right (Helium).
- Atomic Radius (Fr) & Reactivity (Fr):** Indicated by a red arrow pointing from the top-left (Hydrogen) towards the bottom-right (Francium).

The periodic table is divided into several blocks, with elements labeled by their chemical symbols:

- Group 1 (Alkali Metals):** H, Li, Na, K, Rb, Cs, Fr.
- Group 2 (Alkaline Earth Metals):** Be, Mg, Ca, Sr, Ba, Ra.
- Transition Metals (d-block):** Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr.
- Lanthanides and Actinides (f-block):** Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu; Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr.
- Other Elements:** Al, Si, P, S, Cl, Ar; Y, Zr, Nb, Mo, Tc, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb, Te, I, Xe; La, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl, Pb, Bi, Po, At, Rn; Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr.

# The Electron Shielding Effect

Electrons between the nucleus and the valence electrons repel each other making the atom larger, affecting the atomic radius!



# Atomic Radius of Neutral and Charged Species

**Trends in Atomic Radii (nm)**

1							18
H 0.037							He 0.050
Li 0.152	Be 0.111	B 0.088	C 0.077	N 0.070	O 0.066	F 0.064	Ne 0.070
Na 0.186	Mg 0.160	Al 0.143	Si 0.117	P 0.110	S 0.104	Cl 0.099	Ar 0.094
K 0.231	Ca 0.197	Ga 0.122	Ge 0.122	As 0.121	Se 0.117	Br 0.114	Kr 0.109
Rb 0.244	Sr 0.215	In 0.162	Sn 0.140	Sb 0.141	Te 0.137	I 0.133	Xe 0.130
Cs 0.262	Ba 0.217	Tl 0.171	Pb 0.175	Bi 0.146	Po 0.150	At 0.140	Rn 0.140

Li<sup>+</sup>  
0.078

Na<sup>+</sup>  
0.098

K<sup>+</sup>  
133

Rb<sup>+</sup>  
149

Cs<sup>+</sup>  
165

Be<sup>2+</sup>  
0.034

Mg<sup>2+</sup>  
0.079

Ca<sup>2+</sup>  
106

Sr<sup>2+</sup>  
127

Ba<sup>2+</sup>  
143

Al<sup>3+</sup>  
0.057

Ga<sup>3+</sup>  
0.062

In<sup>3+</sup>  
0.092

Tl<sup>3+</sup>  
105

N<sup>3-</sup>  
0.146

O<sup>2-</sup>  
0.140

S<sup>2-</sup>  
0.184

Se<sup>2-</sup>  
0.191

Te<sup>2-</sup>  
0.211

F<sup>-</sup>  
0.133

Cl<sup>-</sup>  
0.181

Br<sup>-</sup>  
0.196











I<sup>-</sup>  
0.220



# Ionic Radius for Cations

**Boosts the  
effective  
nuclear  
charge!**









Radii of Alkali Metal Elements and Ions

	Li 0.152 nm		Li <sup>+</sup> 0.068 nm
	Na 0.156 nm		Na <sup>+</sup> 0.098 nm
	K 0.231 nm		K <sup>+</sup> 0.133 nm
	Rb 0.244 nm		Rb <sup>+</sup> 0.148 nm
	Cs 0.262 nm		Cs <sup>+</sup> 0.167 nm

# Ionic Radii for Anions

Lowers the  
effective  
nuclear  
charge

Atomic radii of the halogen atoms  
and the corresponding halide ion

	F	0.064 nm		F <sup>-</sup>	0.133 nm
	Cl	0.099 nm		Cl <sup>-</sup>	0.181 nm
	Br	0.114 nm		Br <sup>-</sup>	196 pm
	I	0.133 nm		I <sup>-</sup>	219 pm






All radii are in nanometers (nm)  
1 nm = 10<sup>-9</sup> m

# Ionic Radius for an Isoelectronic Group

## The Radii of an Isoelectronic Group of Ions

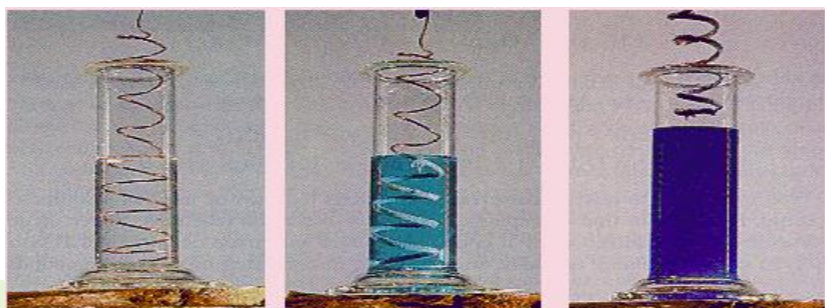
Isoelectronic ions have the same number of electrons.

The more negative an ion is the larger it is and vice versa.

$Z = 8$		$\text{O}^{2-}$ 0.145 nm
$Z = 9$		$\text{F}^-$ 0.133 nm
$Z = 11$		$\text{Na}^+$ 0.098 nm
$Z = 12$		$\text{Mg}^{2+}$ 0.065 nm
$Z = 13$		$\text{Al}^{3+}$ 0.045 nm

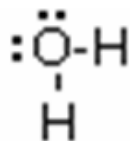
# Complex Ions

- ▶ The ions of the d block and the lower p block have **unfilled d or p orbitals**.
- ▶ These orbitals can accept electrons either an ion or polar molecule, to form a dative bond. This attraction results in the formation of a **complex ion**.
- ▶ A complex ion is made up of **two or more ions or polar molecules** joined together.
- ▶ The molecules or ions that surround the metal ion donating the electrons to form the complex ion are called **ligands**.

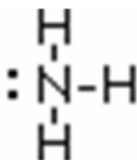


# Complex Ions

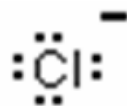
- ▶ Compounds that are formed with complex ions are called **coordination compounds**
- ▶ *Common ligands*



Water



Ammonia



Chloride



Cyanide

- ▶ Complex ions usually have either 4 or 6 ligands.

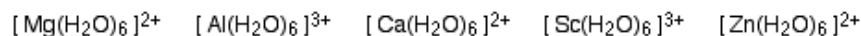
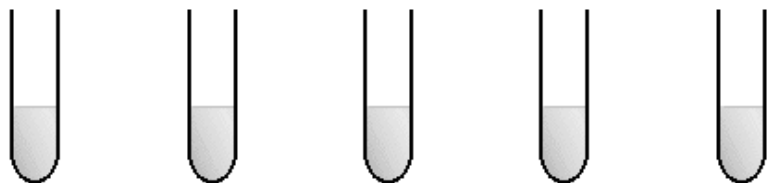




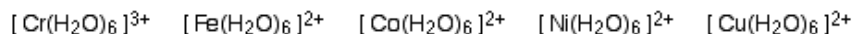
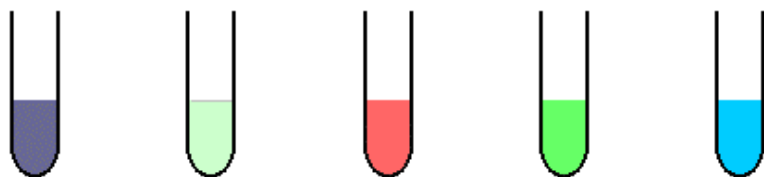
# Complex Ions

- ▶ The formation of complex ions stabilizes the oxidation states of the metal ion and they also affect the solubility of the complex ion.

These ions are colorless



Complex ions have distinct colors



The formation of a complex ion often has a major effect on the color of the solution of metal ion.

# The D Block Colored Compounds

- ▶ In an isolated atom all of the **d sublevel electrons** have the same energy.
- ▶ When an atom is surrounded by charged ions or polar molecules, the electric field from these ions or molecules has a unequal effect on the energies of the various d orbitals and d electrons.
- ▶ The colors of the ions and complex ions of d block elements depends on a variety of factors including:
  - The particular element
  - The oxidation state
  - The kind of ligands bound to the element

Various oxidation  
states of Nickel (II)

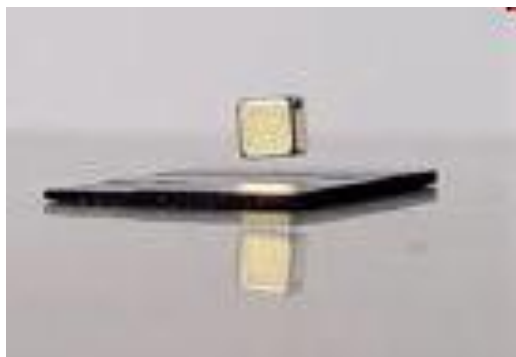


# Colors in the D Block

- ▶ The presence of a partially filled d sublevels in a transition element results in colored compounds.
- ▶ Elements with completely full or completely empty subshells are colorless,
  - For example Zinc which has a full d subshell. Its compounds are white
- ▶ A transition metal ion exhibits color, if it absorbs light in the visible range (400–700 nanometers)
- ▶ If the compound absorbs a particular wavelengths of light its color is the composite of those wavelengths that it does not absorb. It shows the complimentary color.

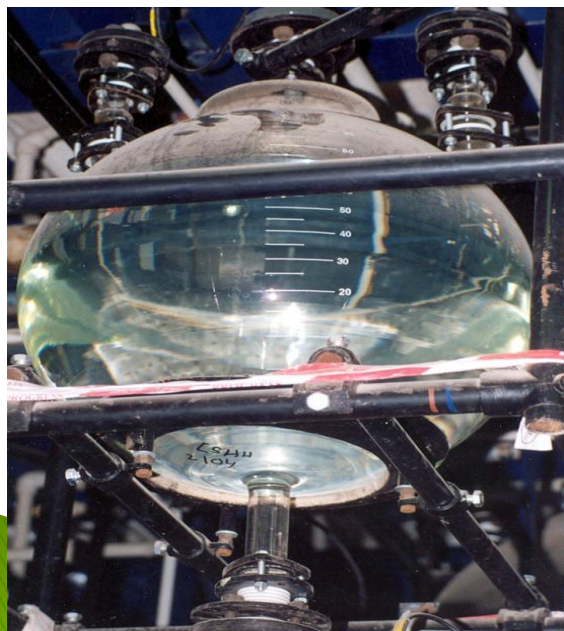


# Magnetic Properties



- ▶ **Paramagnetism** --- Molecules with one or more unpaired electrons are attracted to a magnetic field. The more unpaired electrons in the molecule the stronger the attraction. This type of behavior is called
- ▶ **Diamagnetism** --- Substances with no unpaired electrons are weakly repelled by a magnetic field.
- ▶ Transition metal complexes with unpaired electrons exhibit simple paramagnetism.
- ▶ The degree of paramagnetism depends on the number of unpaired electrons

# Catalytic Behavior



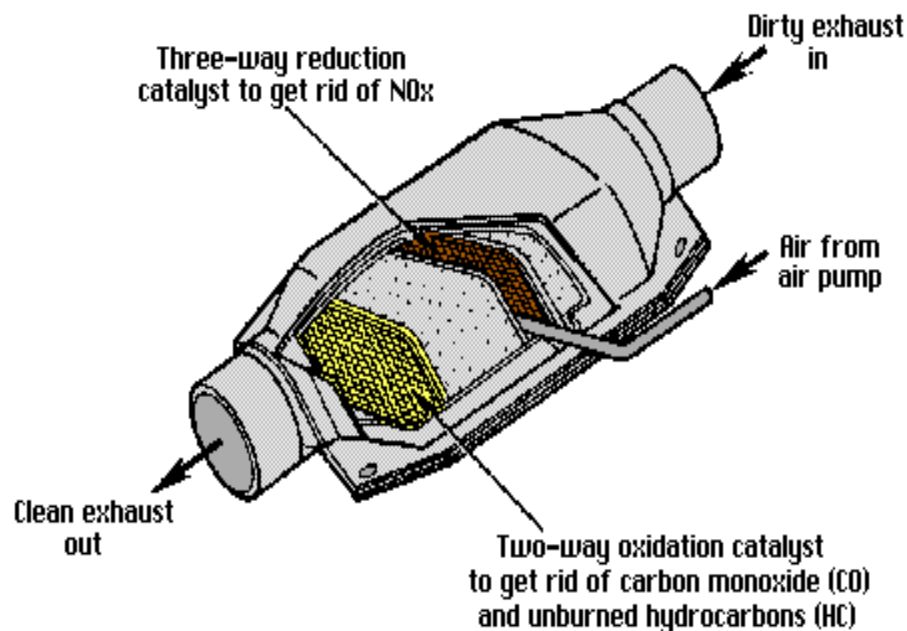
- ▶ Many D block elements are **catalysts** for various reactions
- ▶ **Catalysts** speed up the rate of a chemical reaction without being consumed.
- ▶ The transition metals form complex ions with species that can donate lone pairs of electrons.
- ▶ This results in close contact between the metal ion and the ligand.
- ▶ Transition metals also have a wide variety of oxidation states so they gain and lose electrons in redox reactions



# Some Common D Block Catalysts

- Examples of D block elements that are used as catalysts:

## CATALYTIC CONVERTER

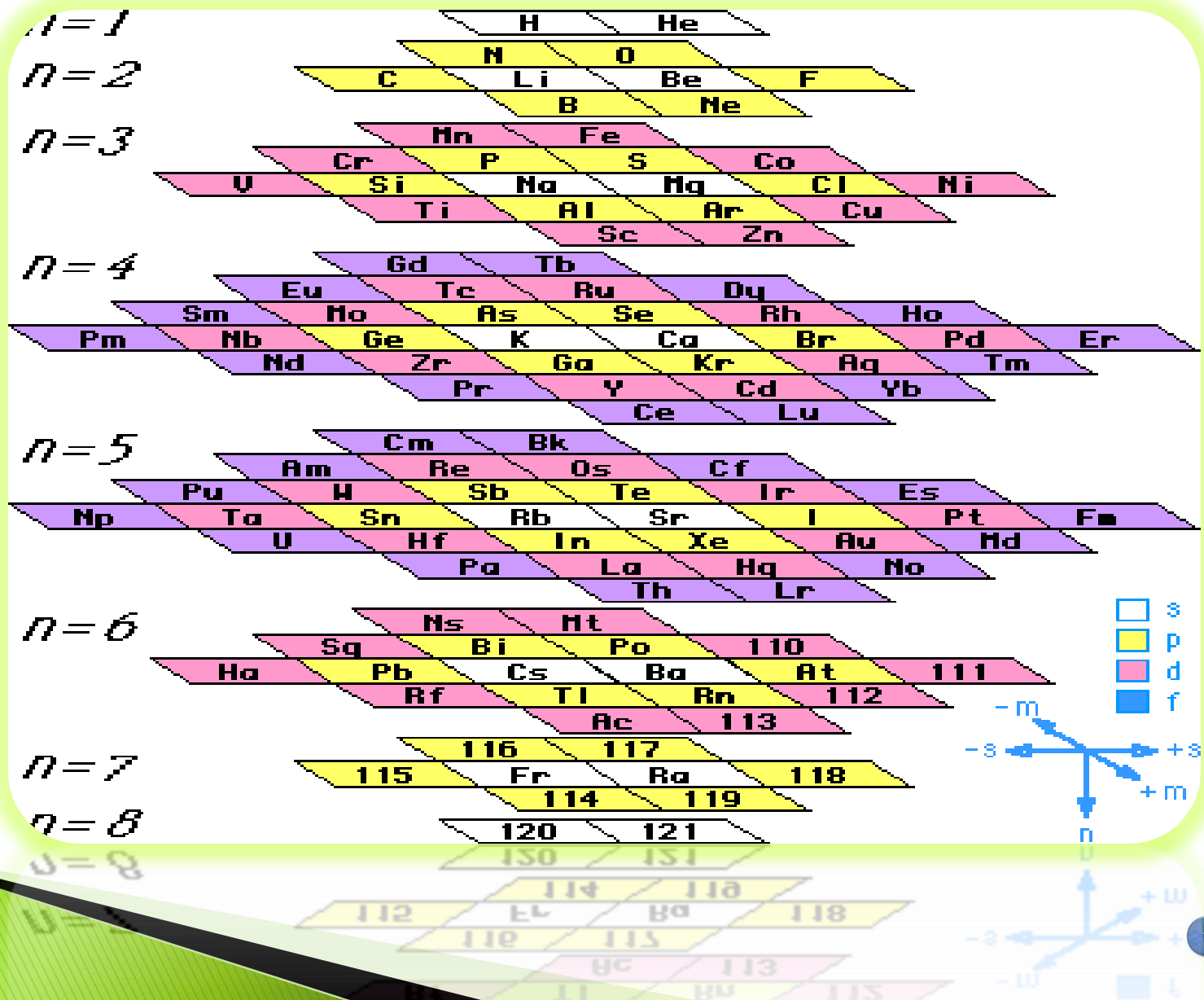


1. Platinum or rhodium is used in a catalytic converter
2.  $\text{MnO}_2$  catalyzes the decomposition of hydrogen peroxide
3.  $\text{V}_2\text{O}_5$  is a catalyst for the contact process
4. Fe in Haber process
5. Ni in conversion of alkenes to alkanes

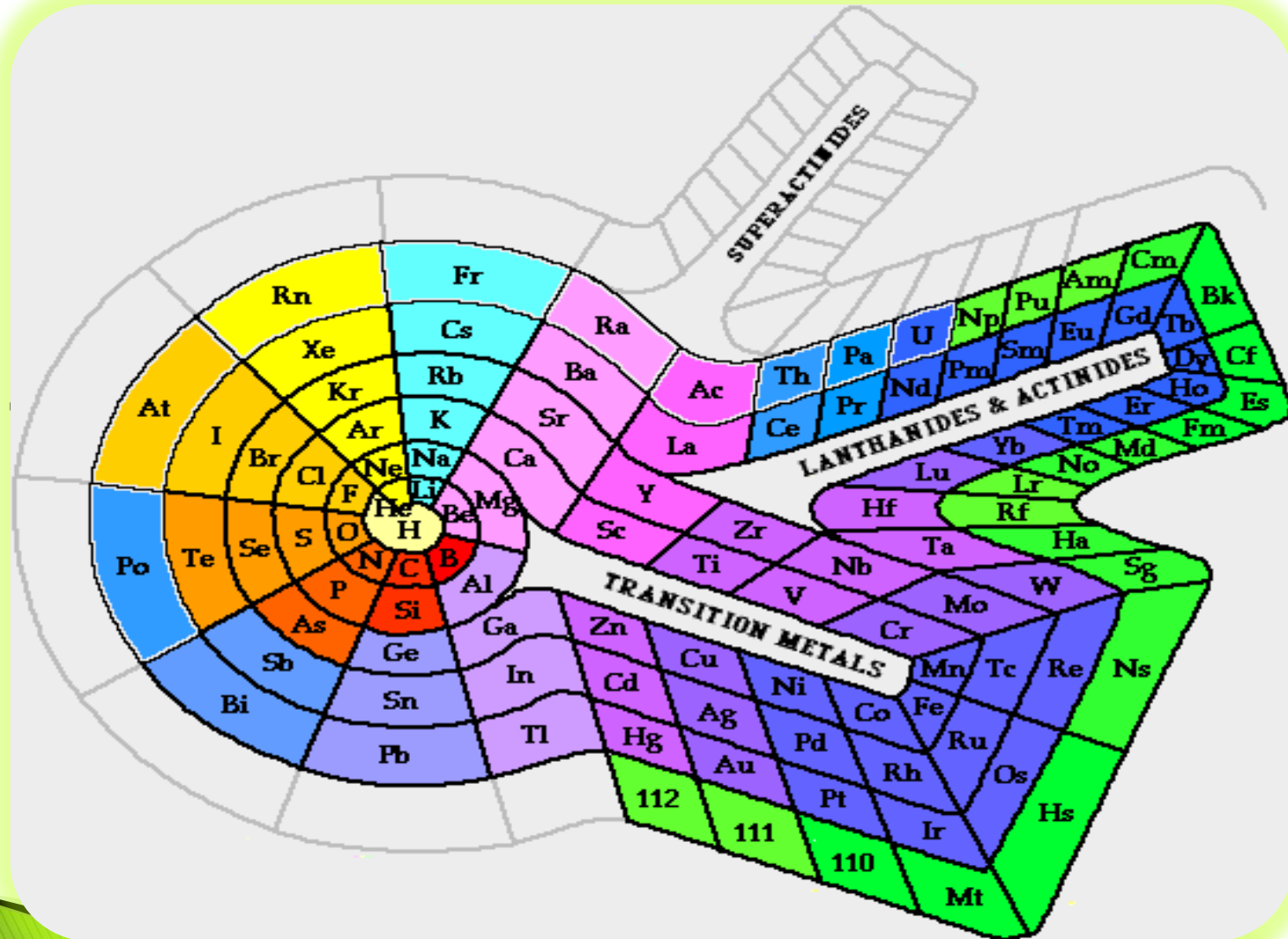
# Alternate Periodic Tables

**Although we are most familiar with the periodic table that Seaborg proposed more than 60 years ago, several alternate designs have been proposed.**

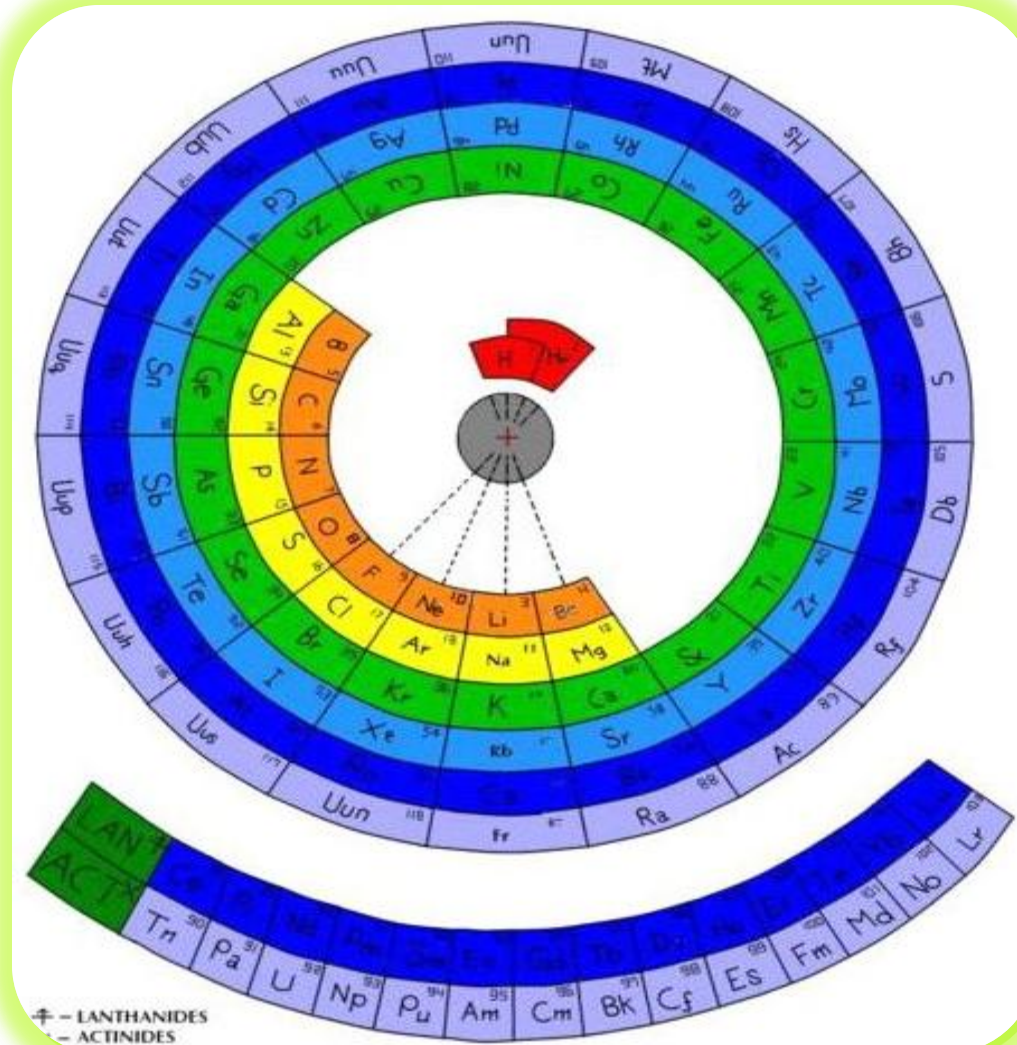
# Alternate Periodic Tables



# Alternate Periodic Tables II



# Alternate Periodic Tables III





# Alternate Periodic Tables IV

